Determining Satellite Era Accumulation Patterns over WAIS Divide: The SEAT Traverse

Lora Koenig, Code 614.1, NASA GSFC

Accumulation, the amount of snow that falls on an ice sheet, is one of the most important inputs for determining the mass balance of an ice sheet   There are, however, relatively few direct accumulation measurements because the most precise measurements come from ice cores at a single point location.

Recently, new large-bandwidth, very-high frequency radars have been developed and used over the ice sheets to image internal layers in the near surface which represent about the past 30-40 years of accumulation. The SEAT traverses are making the link between near surface radar layers and ice cores by collecting both simultaneously across the West Antarctic Ice Sheet (WAIS) Divide region.

The data gathered during the two traverses (Dec. 2010 and Dec. 2011) will allow for a spatially and temporally distributed data set of accumulation to be produced in this region.

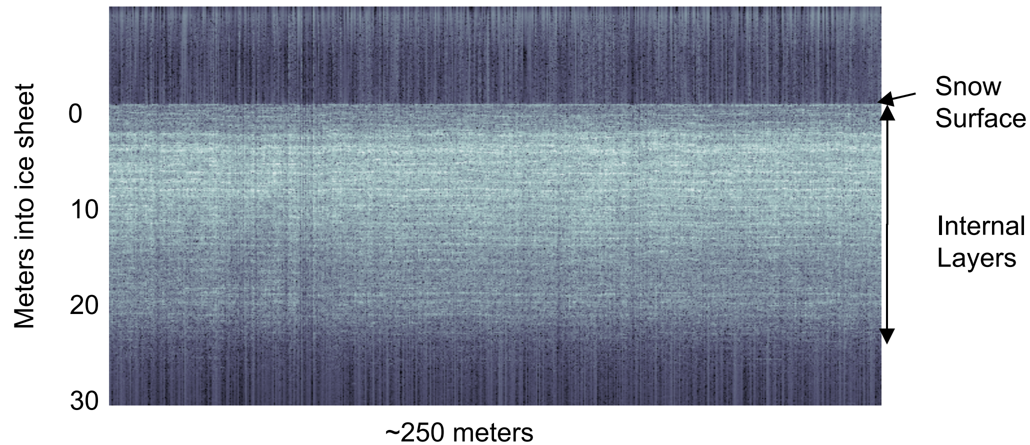

Figure 1: Image of the near surface snow/firn in West Antarctica The laying is used to determine accumulation rates

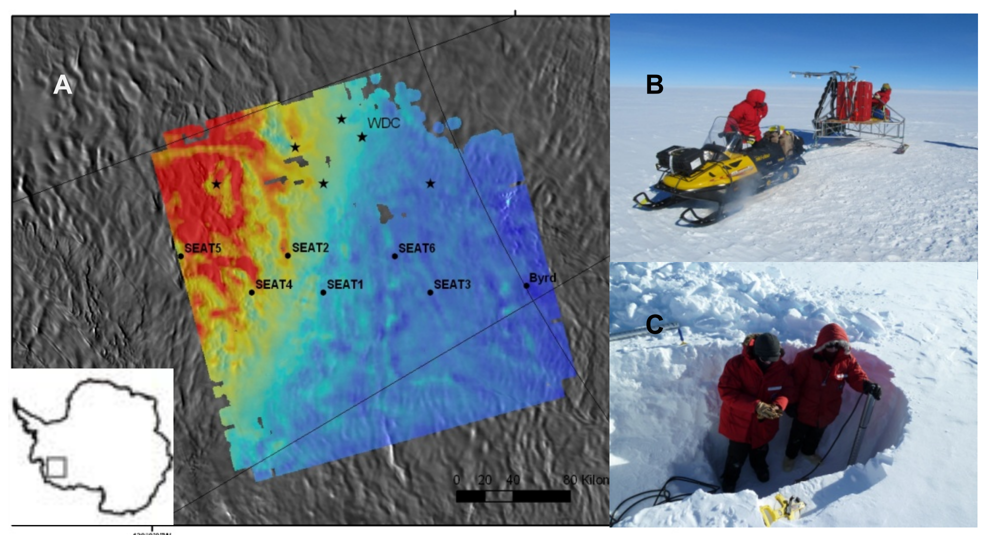

Figure 2: a)Image showing the long term accumulation rates and ice core locations from 2010 (*) and for 2011 (●).
b) Picture of radar sled c) Picture of ice core drill

Name: Lora Koenig, NASA/GSFC
E-mail: lora.s.koenig@nasa.gov
Phone: 301-614-5507

References:
The Center for Remote Sensing of Ice Sheet developed the Snow radar and Ku-band radar used in this research
https://cms.cresis.ku.edu/research/sensors-development/radar

More information on the Satellite Era Accumulation Project website hosted by Co-I Summer Rupper
http://www.geology.byu.edu/employee-profiles/summer-rupper/projects/

Data Sources: This project is a joint NASA/NSF project. The ice cores are being processed by Dr. Summer Rupper at Brigham Young University. The first ice cores were gathered in Dec. 2010 and are still being processed to determine the age/depth scale for the radar layers shown in Figure 1.

Technical Description of Image:
Figure 1: A radar echogram taken near the WAIS Divide Camp on the West Antarctica Ice Sheet. The radar echogram was produced from the Ku-band radar which operates from 12-18 GHz. The bright horizontal layers are from density, or dielectric, changes in the firn. The layers in the image are assumed to be annual accumulation layers. A shallow ice core taken nearby is currently being analyzed for the yearly isotopic signal. The isotopic signal from the ice core in conjunction with the radar layers will allow for the determination of an accumulation rate along the radar echograms.

Figure 2: A) This image shows the large change in long term accumulation (Morse, 2002) across WAIS divide and the locations of the SEAT traverse ice cores. B) Picture showing the radar sled, housing the Snow and Ku-band radars, that is driven between the ice core locations to establish the spatial and temporal accumulation trends. C) The ice core drill, drilling an ice core down to ~20 m or ~30 to 40 years.

Scientific significance: Antarctic precipitation rate is projected to increase up to 20% in the coming century from the predicted warming. This field work and data will be used to produce the first ever spatial and temporal map of accumulation rate from ground measurements to monitor and establish trends from an in-situ measurement.

Relevance for future science and relationship to Decadal Survey: In the future the Satellite Era Accumulation dataset produced from this work can be used to develop accumulation algorithms for satellite records such as the 30 year passive microwave record.

Land Model Calibration for Improved Numerical Weather Prediction

Joseph A. Santanello, Jr., Sujay V. Kumar, and Christa D. Peters-Lidard, Code 614.3, NASA GSFC

Land-atmosphere (L-A) coupling plays a critical role in determining the diurnal evolution of both land surface and planetary boundary layer (PBL) water and energy budgets, and in turn modulates feedbacks with clouds and precipitation that lead to the persistence of dry and wet extremes.

In this study, we examine the impacts of improved specification of **land surface states, anomalies, and fluxes on weather forecasts** from the NASA Unified WRF (NU-WRF) regional model during the prolonged dry conditions of the U. S. Southern Great Plains in Summer 2006.

The improved land initialization and surface flux parameterizations are obtained through the use of a new optimization and uncertainty module in NASA's Land Information System (LIS-OPT), whereby parameter sets are calibrated in the Noah land surface model and appropriated according to the land cover and soil types across the domain.

Results

- LIS-OPT improves the initial condition and evolution of surface fluxes in NU-WRF simulations.
- **Default** (look-up table) parameters lead to large errors in forecasts of temperature, humidity, flux and PBL properties.
- Calibration (**Calibrated**) improves all components of L-A coupling and reduces RMSE in T2m and Q2m by ~32-42%.
- Using calibrated parameters for the offline spinup + coupled runs (**Calibrated**) reduces the total energy bias (heat and moisture) in the system by 91%.

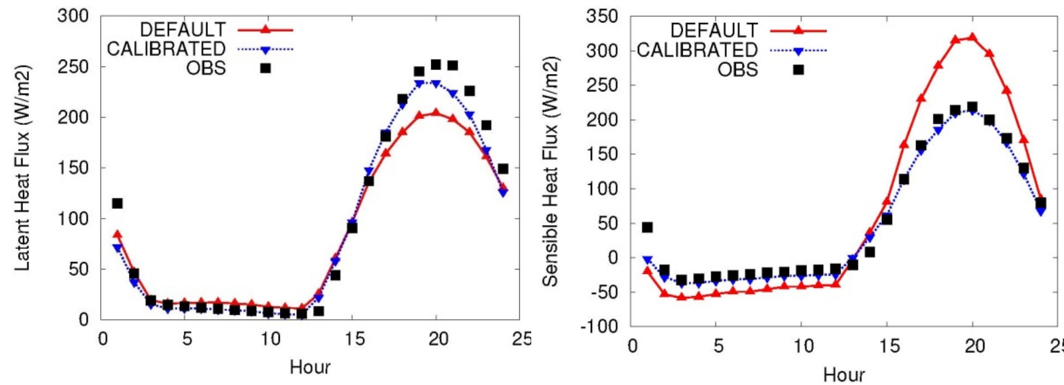

Fig. 1: Mean diurnal cycles of **a)** latent and **b)** sensible heat flux from the offline Noah LSM evaluated across all 19 ARM-SGP sites using default vs. calibrated parameters for the period April-September 2006.

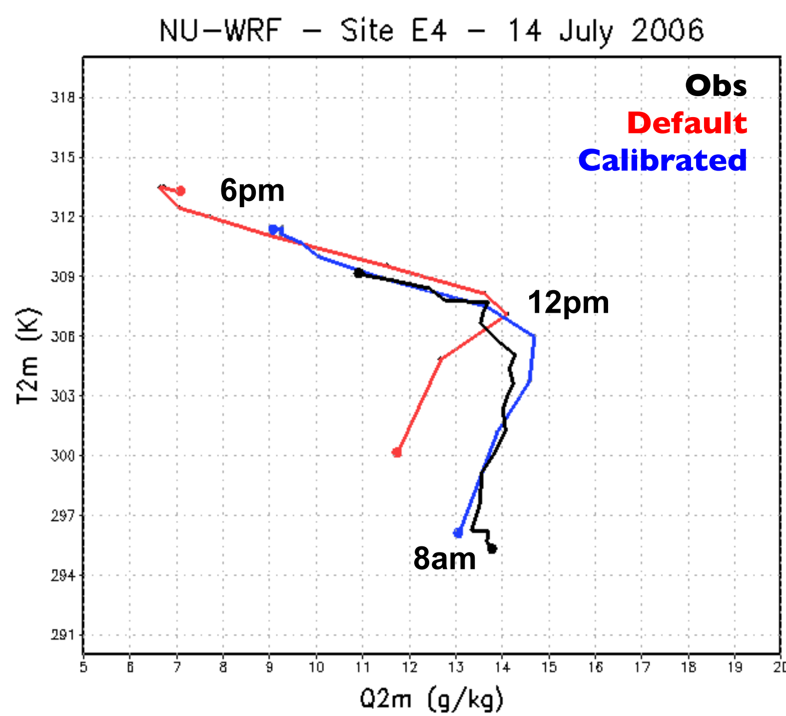

Fig. 2: Daytime co-evolution of near-surface humidity (**Q2m**) and temperature (**T2m**) simulated by NU-WRF at Plevna, KS using default and optimized land surface parameters in the Noah LSM.

Name: Joseph A. Santanello, Jr., NASA-GSFC
E-mail: Joseph.A.Santanello@nasa.gov
Phone: 301-286-7450

References:
• Santanello, J. A. et al., 2011: Diagnosing the Sensitivity of Local Land-Atmosphere Coupling via the Soil Moisture-Boundary Layer Interaction. J. Hydromet., **in press**.
•Santanello, J. A. et al., 2009: A modeling and observational framework for diagnosing local land-atmosphere coupling on diurnal time scales. J. Hydromet, **10,** 577-599.

Data Sources: The community-supported Weather Research and Forecasting (WRF) model has been coupled to NASA-GSFC's Land Information System (LIS) within the NASA Unified WRF (NU-WRF) system, which provides a flexible and high-resolution representation and initialization of land surface physics and states and integrates across GSFC assets in microphysics, radiation, chemistry schemes at satellite-scales. LIS includes a suite of land surface models (e.g. Noah) and a new optimization module (LIS-OPT) for use in parameter estimation studies, and can be run offline to spinup the initial conditions for coupled NU-WRF simulations. Observations for offline and coupled validation as well as the Noah calibration were taken from the ARM-SGP network of in-situ measurements and includes surface meteorological observations of temperature and moisture, and surface flux towers.

Technical Description of Image:
Figure 1: Mean diurnal cycles of sensible and latent heat averaged across 19 ARM-SGP sites over the April-September 2006 period as simulated by the Noah land surface model (using LIS offline) for a 500x5001-km horizontal resolution domain covering the U.S. Southern Great Plains (SGP). The default simulation used look up table values of soil and vegetation parameters based on land cover and soil type maps. The calibrated simulation used parameters estimated from a Genetic Algorithm (GA) in LIS-OPT and were calibrated to minimize the cumulative error in sensible and latent heat flux hourly observations at the sites over the 6 month period. The new parameters were then grouped according to land cover and soil type classification in order to derive parameters for the remainder of the grid cells in the domain.
Figure 2: Diurnal co-evolution (8am-6pm) of 2m-specific humidity (Q2m) and 2m-potential temperature (T2m) on 14 July 2006 as simulated by NU-WRF at the E4 ARM-SGP site using the Noah land surface model with parameter sets that were **a)** default for both the offline and coupled runs ('Default'), **b)** default in the offline run and optimized in the coupled run ('Calibrated-IC only'), and **c)** optimized in both the offline spinup and coupled runs ('Calibrated-Coupled'). Also shown are observations from the E4 site ('Obs'). In addition, mixing diagrams such as this can be used to fully evaluate the heat and moisture components of L-A coupling (not shown).

Scientific significance: The degree of local land-atmosphere coupling (LoCo) is a critical component of prediction models and impacts the simulation of sensible weather, turbulence, convective initiation, and precipitation across a range of scales. Further, the impact of the land surface as the lower boundary condition of energy and water cycling can be significant and therefore it is imperative that the land surface be properly represented in models. This study advances understanding of how improved surface fluxes, and in turn coupled forecasts, can be obtained by calibrating difficult to observe and distribute parameter information. To this end, LIS and NU-WRF are being used as a testbed to develop and test diagnostics to quantify the coupled behavior of models, and has been supported by the NASA AIST, NEWS, MAP and Air Force (AWFA) programs.

Relevance for future science and relationship to Decadal Survey: A straightforward yet robust approach such as this will enable NASA satellites to be used to calibrate and evaluate land models and improve their coupling with the overlying atmosphere. In particular, this calibration approach will incorporate satellite data that offers information across an entire modeling domain at comparable spatial scales to the model grid cell level (rather than limited in-situ site locations as in this study). Examples of current and future satellite data that could be used for calibration include soil moisture (AMSR-E, SMAP), skin temperature (MODIS), and boundary layer properties (AIRS, CALIPSO).